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Metric site index curves for aspen, birch and conifer in the Lake States

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North Central Forest Experiment Station, Forest Service, U.S. Department of Agriculture PROGRAM REPOR

This paper is a contribution from the Aspen-Birch-Conifer Program. The Aspen-Birch-Conifer Program is a coordinated, multi-disciplinary research effort. Its mission is to increase and integrate knowledge of the aspen-birch-conifer forests of the northern Great Lakes region in order to better identify and evaluate resource management alternatives.

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Manuscript approved for publication March 22, 1979

1979

METRIC SITE INDEX CURVES FOR ASPEN, BIRCH, AND CONIFERS IN THE LAKE STATES

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"It is therefore declared that the policy of the United States shall be to coordinate and plan the increasing use of the metric system in the United States . . ."[1]

Site index is the measured or estimated height of dominant and codominant trees at age 50. It is widely used both as an indicator of potential site productivity and as the basis for silvicultural recommendations for Lake States timber species. The manager's handbooks for aspen (Perala 1977), black spruce (Johnston 1977a), and northern white-cedar (Johnston 1977b) require an estimate of site index to use their "Key for Recommendations". Yield tables for all Lake States timber species require an estimate of site index. Also, site index curves have been used to estimate mean height growth of dominant and codominant trees because they are actually cumulative height curves.

Lundgren and Dolid (1970) recognized both the potential error in interpolating between curves and the need to facilitate electronic data processing of information that required an estimate of height or site index. They provided mathematical functions describing published site index curves for 11 Lake States timber species. The purpose of this paper is to complement their work by providing site index equations, curves, and height tables in metric units.

EQUATIONS

Lundgren and Dolid (1970) described published site index curves as:

$$H = b_1 S (1 - e^{b_2 A})^{b_3}$$

where H = total height of trees in feet,
S = site index (height at age 50 years),
A = age in years,
e = base of the natural logarithm,
and b_1, b_2, and b_3 are estimated parameters.

From this equation, site index (S) is linearly related to height (H) at any given age. And H, in meters, can be estimated by expressing S as height in meters at age 50. Therefore, the parameter estimates published by Lundgren and Dolid (1970) are valid for estimating height in meters if site index is also expressed in meters (table 1). (Site index in feet can be converted to site index in meters by multiplying by 0.3048 meters per foot.)

CURVES AND TABLES

The site index curves (figs. 1-9) and height tables (tables 2-10) were produced from the equations in table 1. To facilitate the transfer from feet to meters, the metric site index curves illustrated in figures 1-9 were chosen to correspond as closely as possible to the published site index curves in feet. Tables 2-10 are provided so interpolation between curves is not necessary.

USE AND LIMITATIONS

Several dominant and codominant trees should be measured for height and age to estimate site index. The number of sample trees will depend on the range of heights and ages in the stand. Gevorkiantz (1956) gives a rule-of-thumb for an adequate sample as:

$$n = 5 + R^2/30$$

[1] *Metric Conversion Act of 1975, Public Law 94-168.*

where R = observed range of heights or ages in the stand.

Site index cannot be properly evaluated if dominant and codominant trees have been affected by suppression or fire— aspen site index can be underestimated as much as 3 to 5 meters in stands with a fire history (Stoeckeler 1960). Site index curves should not be used in extremely dense, stagnated stands; in very open stands with excessive crown development; or in stands where the height growth of dominant and codominant trees deviates widely from the trend illustrated by the curves (such as in stands that have developed under uncommon soil or climatic conditions). Also, care must be exercised when estimating site index in young stands. Site index is the mean tree height of dominants and codominants at a specific point in time. Therefore, site index does not change with time. But, it is not uncommon for the estimate of site index to change from one measurement to another, particularly if the estimates are made when the stand is less than 30 years old.

LITERATURE CITED

Gevorkiantz, S. R. 1956. Site index curves for aspen in the Lake States. U.S. Dep Agric. For. Serv. Tech. Note 464, 2 p. U.S. Dep. Agric. For. Serv., Lake States For. Exp. Stn., St. Paul, MN.

Johnston, William F. 1977a. Manager's handbook for black spruce in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-34, 18 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Johnston, William F. 1977b. Manager's handbook for northern white-cedar in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-35, 18 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Lundgren, Allen L., and William A. Dolid. 1970. Biological growth functions describe published site index curves for Lake States timber species. U.S. Dep. Agric. For. Serv., Res. Pap. NC-36, 9 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Perala, Donald A. 1977. Manager's handbook for aspen in the north-central States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-36, 30 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Stoeckeler, Joseph H. 1960. Soil factors affecting the growth of quaking aspen in the Lake States. Univ. Minnesota Agric. Exp. Stn., Tech. Bull. 233, 48 p. St. Paul, MN.

Table 1.—*Parameters of the equation describing metric site index curves*[1] (derived from Lundgren and Dolid 1970)

Species	Parameters			Standard error	Maximum error
	b_1	b_2	b_3	------meters------	
Red pine	1.890	−0.01979	1.3892	.19	.43
Jack pine	1.633	−0.02233	1.2419	.15	.34
White pine	1.966	−0.02399	1.8942	.20	.52
Balsam fir	1.437	−0.02266	0.9381	.21	.58
Black spruce	1.762	−0.02011	1.2307	.22	.58
Tamarack	1.547	−0.02246	1.1129	.16	.43
Northern white-cedar	1.973	−0.01535	1.0895	.20	.52
Aspen	1.480	−0.02140	0.9377	.12	.34
Paper birch	1.598	−0.01938	0.9824	.10	.18

[1]Height = b_1 (Site Index (meters)) $(1-e^{b_2 (Age)})^{b_3}$.

Table 2.— *Red pine height as related to site index and age*
(In meters)

Site index	Age (years)										
	20	30	40	50	60	70	80	90	100	110	120
10	4.0	6.2	8.2	9.9	11.4	12.7	13.7	14.6	15.4	16.0	16.5
11	4.4	6.8	9.0	10.9	12.5	13.9	15.1	16.1	16.9	17.6	18.2
12	4.8	7.4	9.8	11.9	13.7	15.2	16.5	17.6	18.4	19.2	19.8
13	5.2	8.0	10.6	12.9	14.8	16.5	17.9	19.0	20.0	20.8	21.5
14	5.6	8.7	11.4	13.9	16.0	17.7	19.2	20.5	21.5	22.4	23.1
15	6.0	9.3	12.3	14.9	17.1	19.0	20.6	21.9	23.1	24.0	24.8
16	6.4	9.9	13.1	15.9	18.2	20.3	22.0	23.4	24.6	25.6	26.4
17	6.8	10.5	13.9	16.8	19.4	21.5	23.3	24.9	26.1	27.2	28.1
18	7.2	11.1	14.7	17.8	20.5	22.8	24.7	26.3	27.7	28.8	29.7
19	7.6	11.8	15.5	18.8	21.7	24.1	26.1	27.8	29.2	30.4	31.4
20	8.0	12.4	16.3	19.8	22.8	25.3	27.5	29.3	30.7	32.0	33.0
21	8.4	13.0	17.2	20.8	23.9	26.6	28.8	30.7	32.3	33.6	34.7
22	8.8	13.6	18.0	21.8	25.1	27.9	30.2	32.2	33.8	35.2	36.3
23	9.2	14.2	18.8	22.8	26.2	29.1	31.6	33.6	35.4	36.8	38.0
24	9.6	14.9	19.6	23.8	27.4	30.4	33.0	35.1	36.9	38.4	39.6
25	10.0	15.5	20.4	24.8	28.5	31.7	34.3	36.6	38.4	40.0	41.3

Table 3.—*Jack pine height as related to site index and age*
(In meters)

Site index	Age (years)								
	20	30	40	50	60	70	80	90	100
9	4.1	6.0	7.6	9.0	10.1	11.0	11.7	12.3	12.8
10	4.6	6.7	8.5	10.0	11.2	12.2	13.0	13.7	14.2
11	5.1	7.4	9.3	11.0	12.3	13.4	14.3	15.0	15.6
12	5.5	8.0	10.2	12.0	13.4	14.6	15.6	16.4	17.0
13	6.0	8.7	11.0	13.0	14.6	15.9	16.9	17.8	18.4
14	6.4	9.4	11.9	14.0	15.7	17.1	18.2	19.1	19.9
15	6.9	10.1	12.7	15.0	16.8	18.3	19.5	20.5	21.3
16	7.4	10.7	13.6	16.0	17.9	19.5	20.8	21.9	22.7
17	7.8	11.4	14.4	17.0	19.0	20.7	22.1	23.2	24.1
18	8.3	12.1	15.3	18.0	20.2	22.0	23.4	24.6	25.5
19	8.7	12.7	16.1	19.0	21.3	23.2	24.7	25.9	27.0
20	9.2	13.4	17.0	20.0	22.4	24.4	26.0	27.3	28.4
21	9.6	14.1	17.8	21.0	23.5	25.6	27.3	28.7	29.8
22	10.1	14.7	18.7	22.0	24.6	26.8	28.6	30.0	31.2

Table 4.—*White pine height as related to site index and age*
(In meters)

Site index	Age (years)										
	20	30	40	50	60	70	80	90	100	110	120
10	3.2	5.6	7.9	10.0	11.8	13.3	14.6	15.6	16.4	17.1	17.6
11	3.5	6.1	8.7	11.0	13.0	14.6	16.0	17.1	18.1	18.8	19.4
12	3.8	6.7	9.5	12.0	14.1	16.0	17.5	18.7	19.7	20.5	21.1
13	4.1	7.2	10.2	13.0	15.3	17.3	18.9	20.3	21.3	22.2	22.9
14	4.4	7.8	11.0	14.0	16.5	18.6	20.4	21.8	23.0	23.9	24.7
15	4.7	8.3	11.8	15.0	17.7	19.9	21.8	23.4	24.6	25.6	26.4
16	5.1	8.9	12.6	15.9	18.8	21.3	23.3	24.9	26.3	27.3	28.2
17	5.4	9.4	13.4	16.9	20.0	22.6	24.7	26.5	27.9	29.0	30.0
18	5.7	10.0	14.2	17.9	21.2	23.9	26.2	28.1	29.5	30.8	31.7
19	6.0	10.6	15.0	18.9	22.4	25.3	27.7	29.6	31.2	32.5	33.5
20	6.3	11.1	15.8	19.9	23.6	26.6	29.1	31.2	32.8	34.2	35.2
21	6.6	11.7	16.5	20.9	24.7	27.9	30.6	32.7	34.5	35.9	37.0
22	7.0	12.2	17.3	21.9	25.9	29.3	32.0	34.3	36.1	37.6	38.8
23	7.3	12.8	18.1	22.9	27.1	30.6	33.5	35.8	37.8	39.3	40.5
24	7.6	13.3	18.9	23.9	28.3	31.9	34.9	37.4	39.4	41.0	42.3
25	7.9	13.9	19.7	24.9	29.4	33.2	36.4	39.0	41.0	42.7	44.0

Table 5.—*Balsam fir height as related to site index and age*
(In meters)

Site Index	Breast height age (years)						
	20	30	40	50	60	70	80
9	5.0	6.7	8.0	9.0	9.8	10.4	10.9
10	5.6	7.4	8.8	10.0	10.9	11.6	12.2
11	6.1	8.1	9.7	11.0	12.0	12.8	13.4
12	6.7	8.9	10.6	12.0	13.1	13.9	14.6
13	7.2	9.6	11.5	13.0	14.1	15.1	15.8
14	7.8	10.4	12.4	14.0	15.2	16.2	17.0
15	8.4	11.1	13.3	15.0	16.3	17.4	18.2
16	8.9	11.8	14.1	16.0	17.4	18.5	19.5
17	9.5	12.6	15.0	17.0	18.5	19.7	20.7
18	10.0	13.3	15.9	18.0	19.6	20.9	21.9
19	10.6	14.1	16.8	19.0	20.7	22.0	23.1
20	11.1	14.8	17.7	20.0	21.8	23.2	24.3
21	11.7	15.6	18.6	21.0	22.8	24.3	25.5
22	12.3	16.3	19.5	22.0	23.9	25.5	26.7

Table 6.—*Black spruce height as related to site index and age*
(In meters)

Site index	Age (years)										
	20	30	40	50	60	70	80	90	100	110	120
6	2.7	4.0	5.1	6.0	6.8	7.5	8.0	8.5	8.9	9.2	9.4
7	3.2	4.7	5.9	7.0	8.0	8.7	9.4	9.9	10.3	10.7	11.0
8	3.6	5.3	6.8	8.0	9.1	10.0	10.7	11.3	11.8	12.2	12.6
9	4.1	6.0	7.6	9.1	10.2	11.2	12.0	12.7	13.3	13.7	14.1
10	4.5	6.6	8.5	10.1	11.4	12.5	13.4	14.1	14.8	15.3	15.7
11	5.0	7.3	9.3	11.1	12.5	13.7	14.7	15.6	16.2	16.8	17.3
12	5.4	8.0	10.2	12.1	13.7	15.0	16.1	17.0	17.7	18.3	18.8
13	5.9	8.6	11.0	13.1	14.8	16.2	17.4	18.4	19.2	19.9	20.4
14	6.3	9.3	11.9	14.1	15.9	17.5	18.7	19.8	20.7	21.4	22.0
15	6.8	10.0	12.7	15.1	17.1	18.7	20.1	21.2	22.1	22.9	23.5
16	7.2	10.6	13.6	16.1	18.2	20.0	21.4	22.6	23.6	24.4	25.1
17	7.7	11.3	14.4	17.1	19.3	21.2	22.8	24.0	25.1	26.0	26.7
18	8.1	12.0	15.3	18.1	20.5	22.5	24.1	25.5	26.6	27.5	28.3
19	8.6	12.6	16.1	19.1	21.6	23.7	25.4	26.9	28.1	29.0	29.8
20	9.0	13.3	17.0	20.1	22.8	24.9	26.8	28.3	29.5	30.6	31.4
21	9.5	14.0	17.8	21.1	23.9	26.2	28.1	29.7	31.0	32.1	33.0
22	9.9	14.6	18.7	22.1	25.0	27.4	29.4	31.1	32.5	33.6	34.5

Table 7.—*Tamarack height as related to site index and age*
(In meters)

Site index	Age (years)										
	20	30	40	50	60	70	80	90	100	110	120
6	3.0	4.2	5.2	6.0	6.6	7.2	7.6	7.9	8.2	8.4	8.6
7	3.5	4.9	6.1	7.0	7.7	8.4	8.9	9.2	9.6	9.8	10.0
8	4.0	5.6	6.9	8.0	8.9	9.6	10.1	10.6	10.9	11.2	11.4
9	4.5	6.3	7.8	9.0	10.0	10.7	11.4	11.9	12.3	12.6	12.9
10	5.0	7.0	8.6	10.0	11.1	11.9	12.6	13.2	13.7	14.0	14.3
11	5.5	7.7	9.5	11.0	12.2	13.1	13.9	14.5	15.0	15.4	15.7
12	6.0	8.4	10.4	12.0	13.3	14.3	15.2	15.8	16.4	16.8	17.2
13	6.5	9.1	11.2	13.0	14.4	15.5	16.4	17.2	17.8	18.2	18.6
14	7.0	9.8	12.1	14.0	15.5	16.7	17.7	18.5	19.1	19.6	20.0
15	7.5	10.5	13.0	15.0	16.6	17.9	19.0	19.8	20.5	21.0	21.5
16	8.0	11.2	13.8	16.0	17.7	19.1	20.2	21.1	21.9	22.4	22.9
17	8.5	11.9	14.7	17.0	18.8	20.3	21.5	22.5	23.2	23.8	24.3
18	9.0	12.6	15.6	18.0	19.9	21.5	22.8	23.8	24.6	25.2	25.8
19	9.5	13.3	16.4	19.0	21.0	22.7	24.0	25.1	26.0	26.6	27.2
20	10.0	14.0	17.3	20.0	22.1	23.9	25.3	26.4	27.3	28.0	28.6
21	10.5	14.7	18.2	21.0	23.2	25.1	26.6	27.7	28.7	29.4	30.1
22	11.0	15.4	19.0	22.0	24.3	26.3	27.8	29.1	30.1	30.8	31.5

Table 8.—*Northern white-cedar height as related to site index and age*
(In meters)

Site	Age (years)								
index	20	30	40	50	60	70	80	90	100
6	2.8	4.0	5.1	6.0	6.8	7.5	8.1	8.6	9.1
7	3.2	4.7	5.9	7.0	7.9	8.8	9.5	10.1	10.6
8	3.7	5.3	6.8	8.0	9.1	10.0	10.8	11.5	12.1
9	4.2	6.0	7.5	9.0	10.2	11.3	12.2	13.0	13.6
10	4.6	6.7	8.4	10.0	11.3	12.5	13.5	14.4	15.1
11	5.1	7.3	9.3	11.0	12.5	13.8	14.9	15.8	16.7
12	5.6	8.0	10.1	12.0	13.6	15.0	16.2	17.3	18.2
13	6.0	8.7	11.0	13.0	14.8	16.3	17.6	18.7	19.7
14	6.5	9.3	11.8	14.0	15.9	17.5	18.9	20.2	21.2
15	6.9	10.0	12.7	15.0	17.0	18.8	20.3	21.6	22.7
16	7.4	10.7	13.5	16.0	18.2	20.0	21.6	23.0	24.2
17	7.9	11.3	14.4	17.0	19.3	21.3	23.0	24.5	25.7
18	8.3	12.0	15.2	18.0	20.4	22.5	24.3	25.9	27.3
19	8.8	12.7	16.0	19.0	21.6	23.8	25.7	27.4	28.8
20	9.3	13.3	16.9	20.0	22.7	25.0	27.1	28.8	30.3

Table 9.—*Aspen height as related to site index and age*
(In meters)

Site	Age (years)						
Index	20	30	40	50	60	70	80
11	6.1	8.1	9.7	11.0	12.0	12.8	13.5
12	6.6	8.8	10.6	12.0	13.1	14.0	14.7
13	7.2	9.5	11.5	13.0	14.2	15.2	16.0
14	7.7	10.3	12.3	14.0	15.3	16.3	17.2
15	8.3	11.0	13.2	15.0	16.4	17.5	18.4
16	8.8	11.8	14.1	16.0	17.5	18.7	19.6
17	9.4	12.5	15.0	17.0	18.6	19.8	20.9
18	9.9	13.2	15.9	18.0	19.7	21.0	22.1
19	10.5	14.0	16.7	19.0	20.7	22.2	23.3
20	11.0	14.7	17.6	20.0	21.8	23.3	24.6
21	11.6	15.4	18.5	21.0	22.9	24.5	25.8
22	12.1	16.2	19.4	22.0	24.0	25.7	27.0
23	12.7	16.9	20.3	23.0	25.1	26.8	28.2
24	13.2	17.6	21.1	24.0	26.2	28.0	29.5
25	13.8	18.4	22.0	25.0	27.3	29.2	30.7

Table 10.—*Paper birch height as related to site index and age*
(In meters)

Site	Age (years)						
Index	20	30	40	50	60	70	80
11	5.8	7.9	9.6	11.0	12.2	13.1	13.9
12	6.3	8.6	10.5	12.0	13.3	14.3	15.2
13	6.8	9.3	11.3	13.0	14.4	15.5	16.4
14	7.3	10.0	12.2	14.0	15.5	16.7	17.7
15	7.9	10.7	13.1	15.0	16.6	17.9	19.0
16	8.4	11.4	13.9	16.0	17.7	19.1	20.2
17	8.9	12.2	14.8	17.0	18.8	20.3	21.5
18	9.4	12.9	15.7	18.0	19.9	21.5	22.8
19	10.0	13.6	16.6	19.0	21.0	22.7	24.0
20	10.5	14.3	17.4	20.0	22.1	23.9	25.3
21	11.0	15.0	18.3	21.0	23.2	25.0	26.5
22	11.5	15.7	19.2	22.0	24.3	26.2	27.8
23	12.0	16.4	20.0	23.0	25.4	27.4	29.1
24	12.6	17.2	20.9	24.0	26.5	28.6	30.3
25	13.1	17.9	21.8	25.0	27.6	29.8	31.6

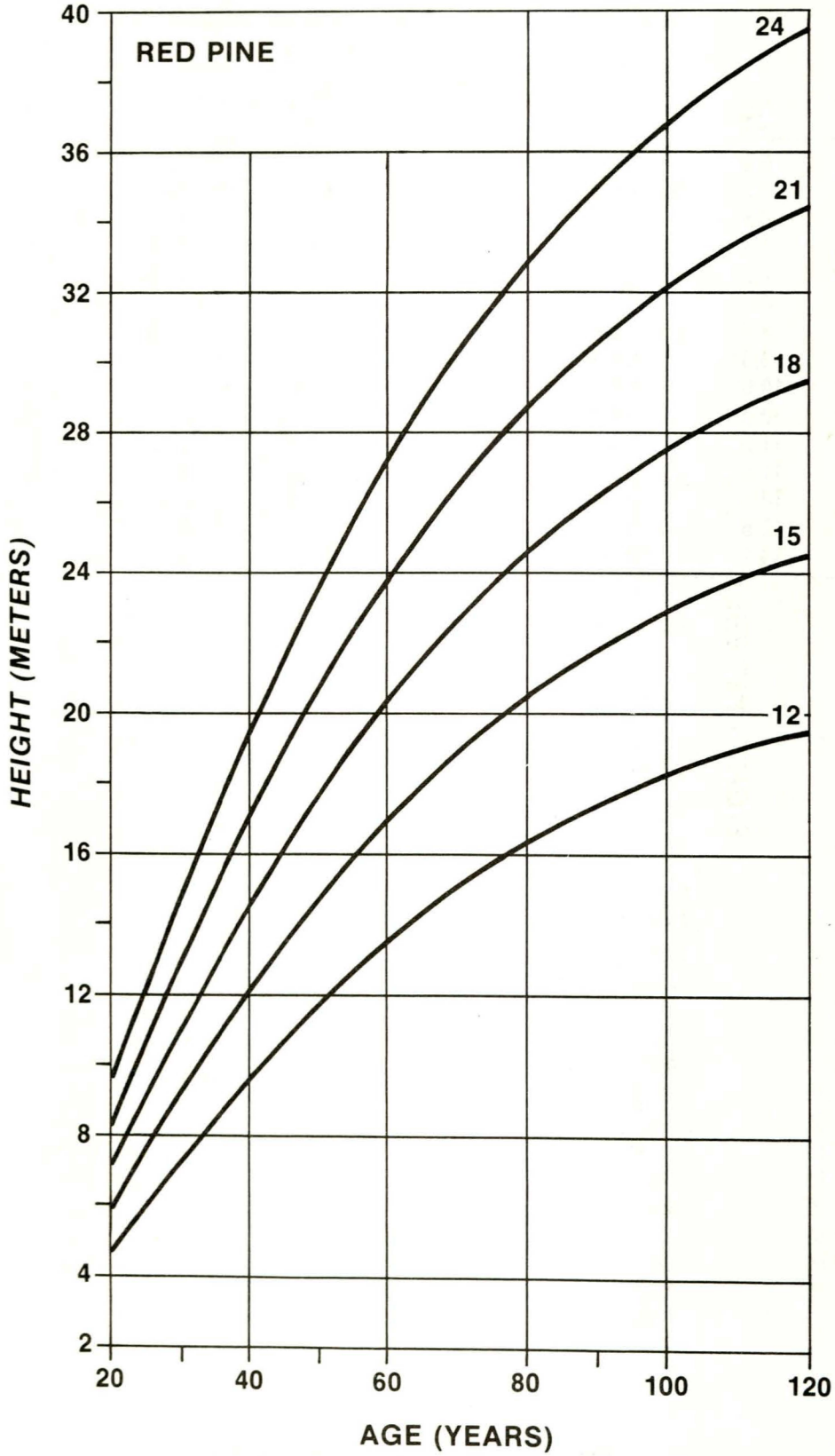

Figure 1.—*Red pine site index curves.*

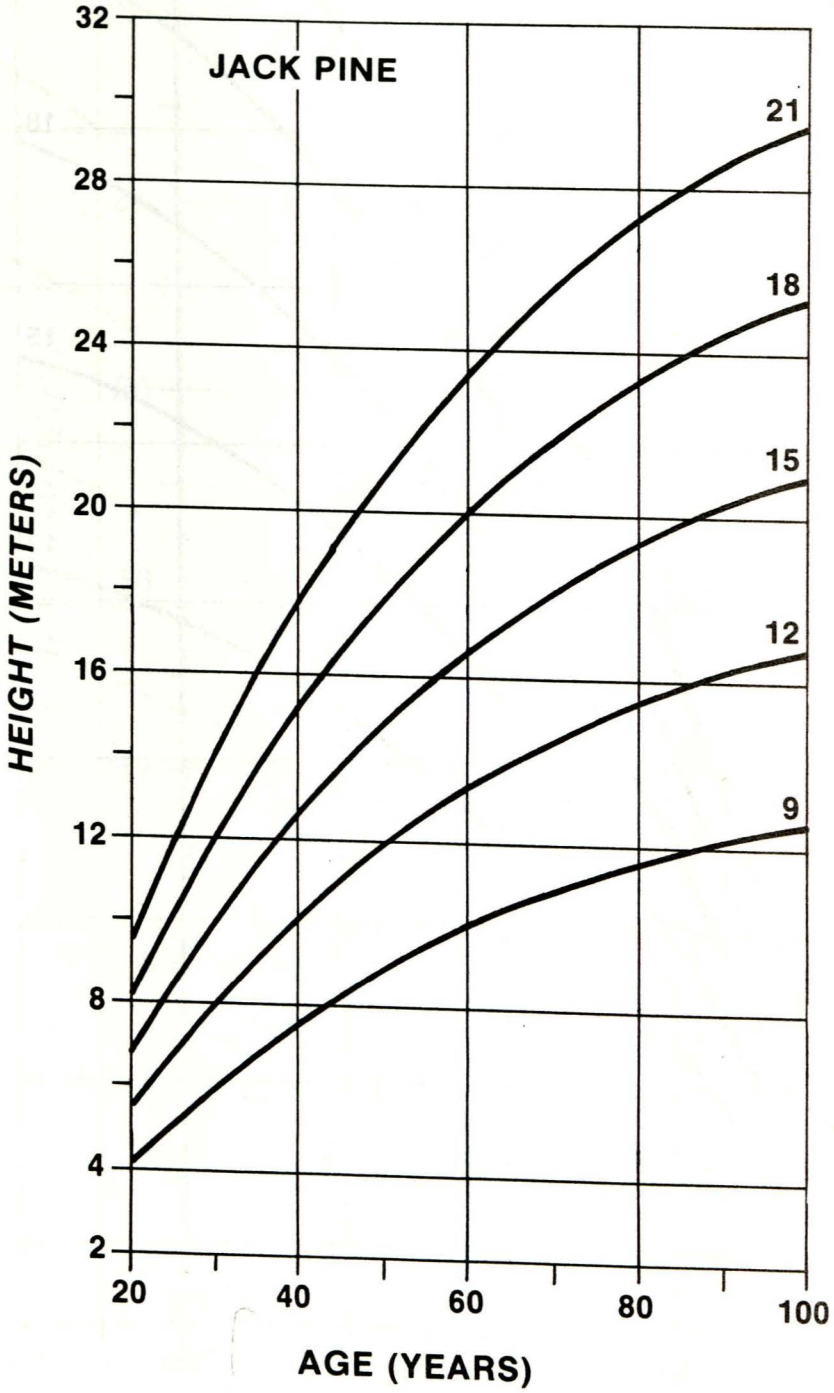

Figure 2.—*Jack pine site index curves.*

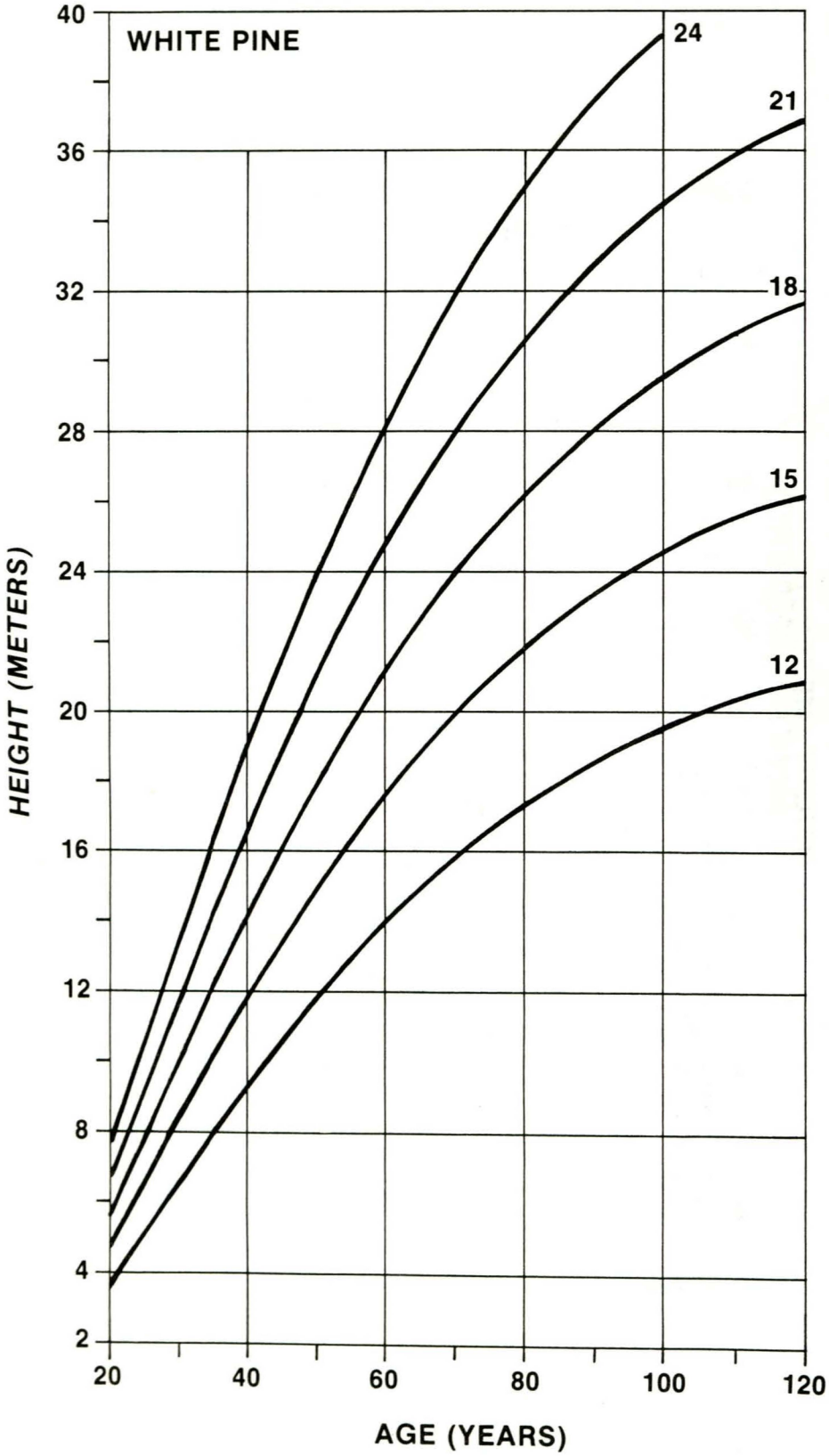

Figure 3.—*White pine site index curves.*

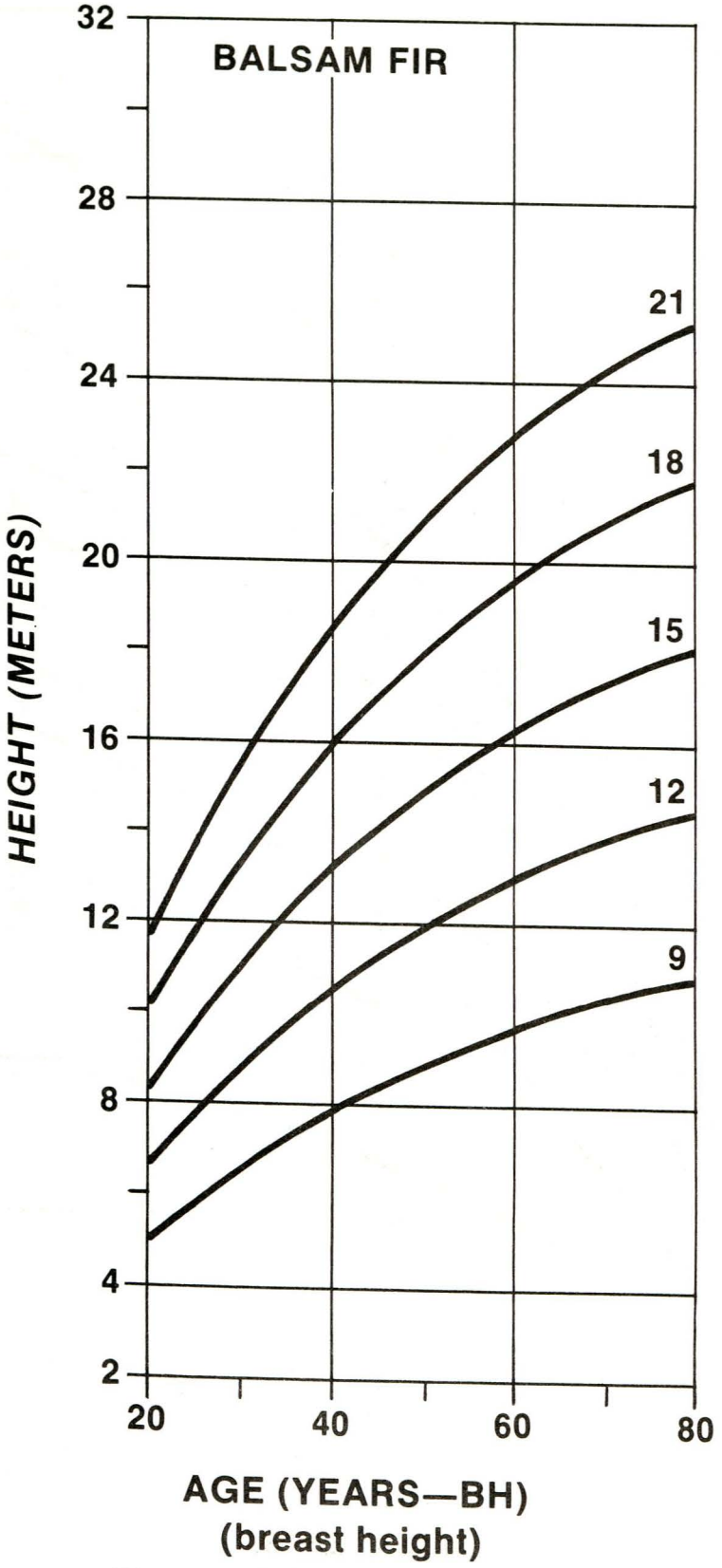

Figure 4.—*Balsam fir site index curves.*

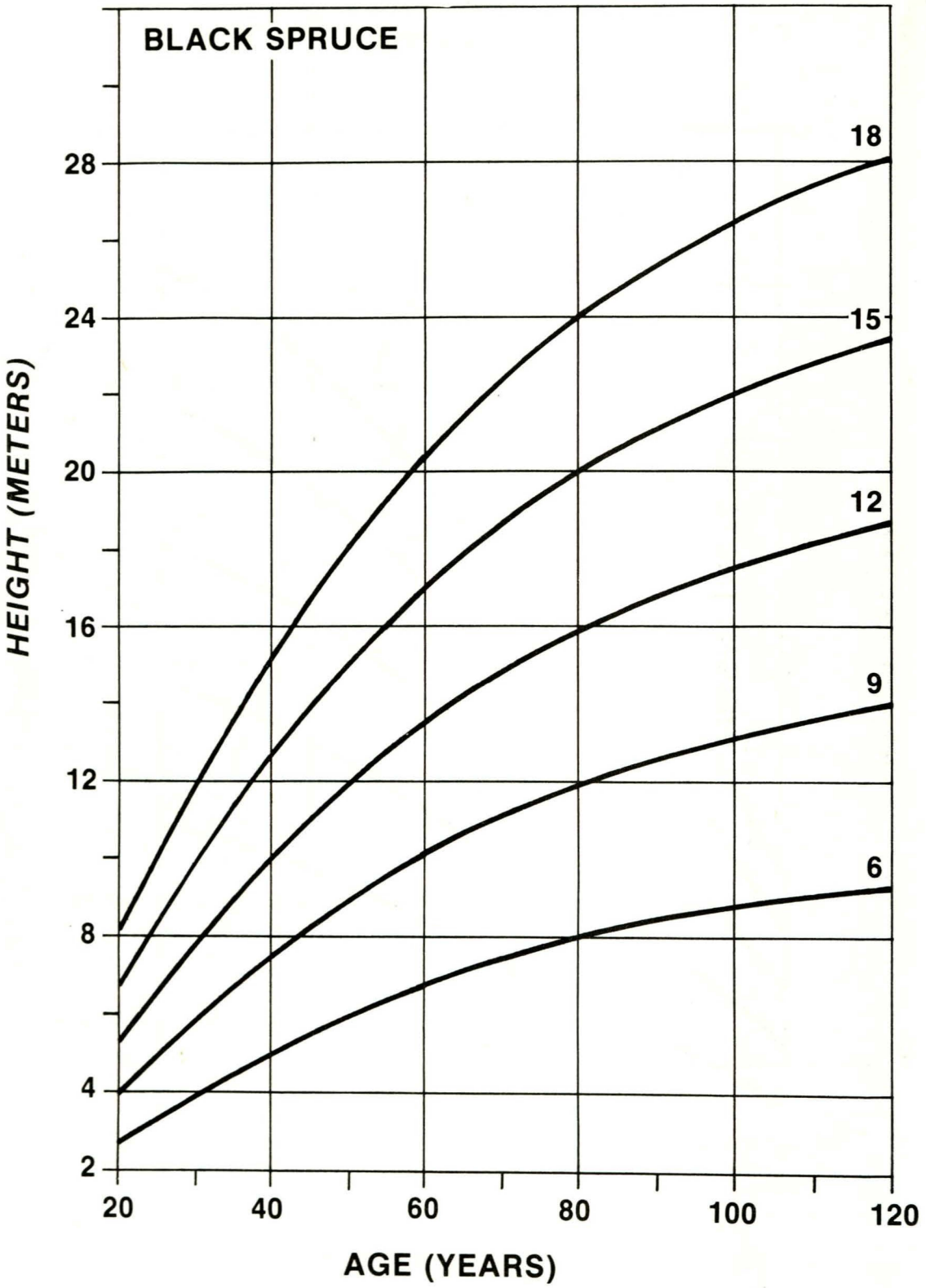

Figure 5.—*Black spruce site index curves.*

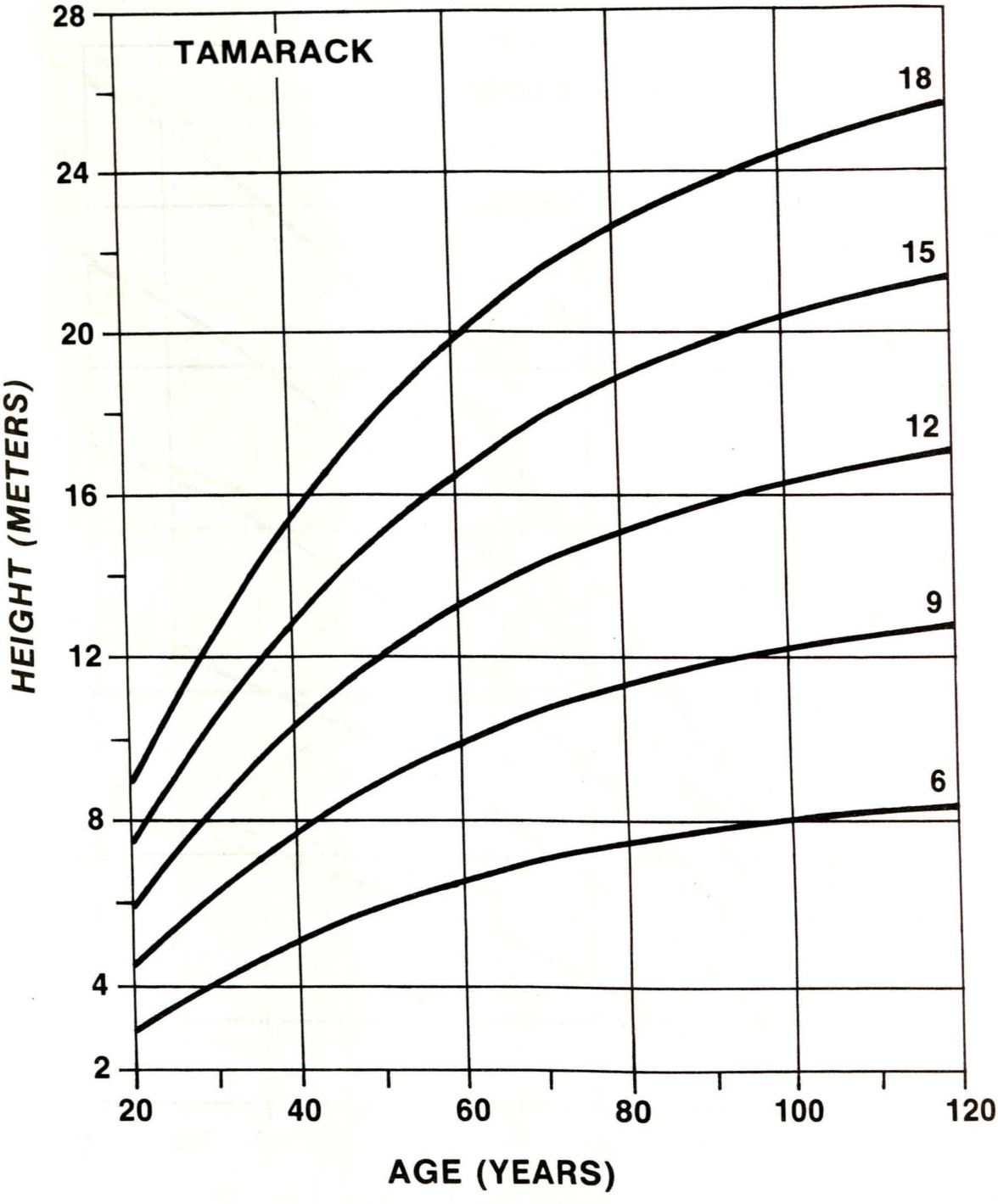

Figure 6.—*Tamarack site index curves.*

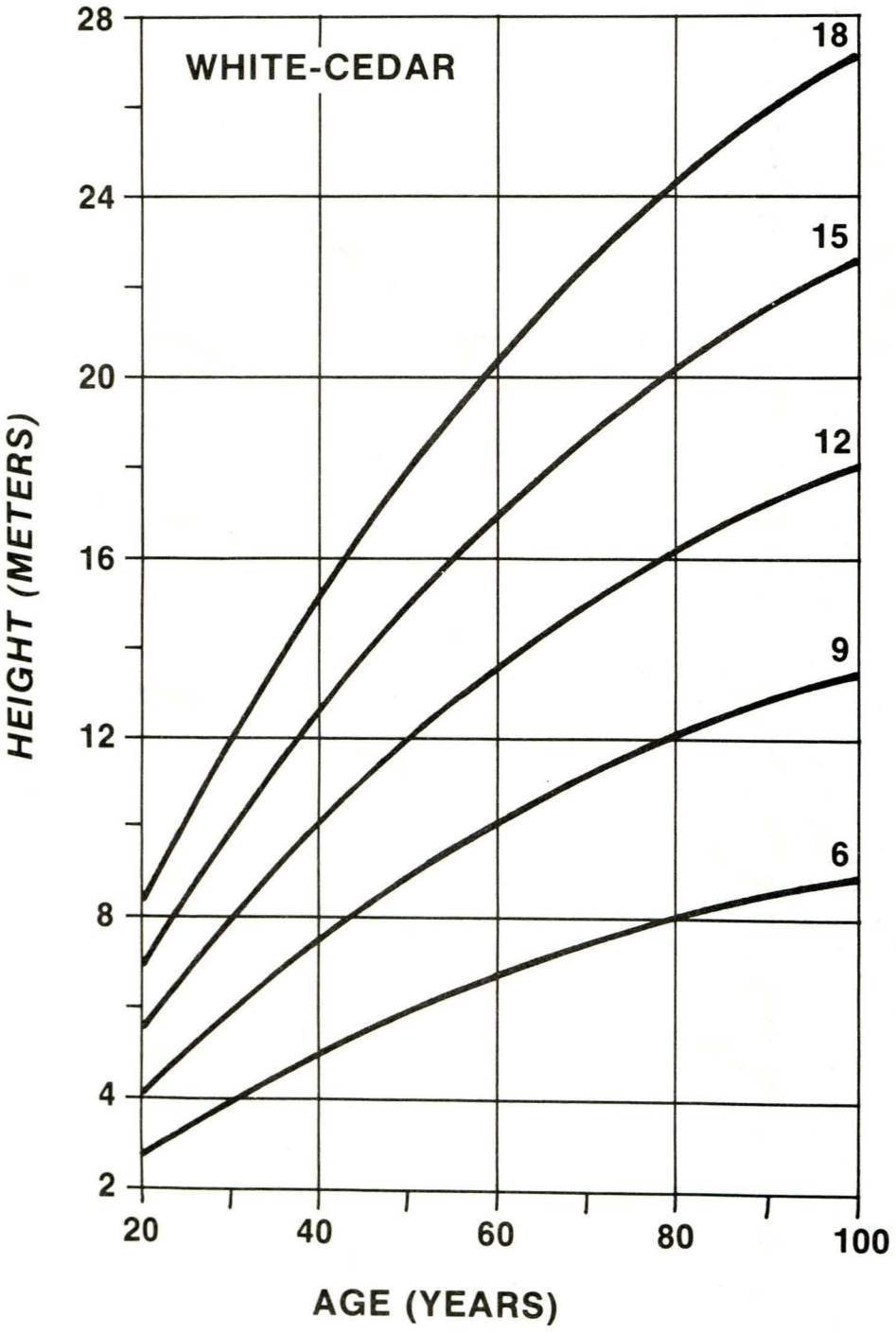

Figure 7.—*Northern white-cedar site index curves.*

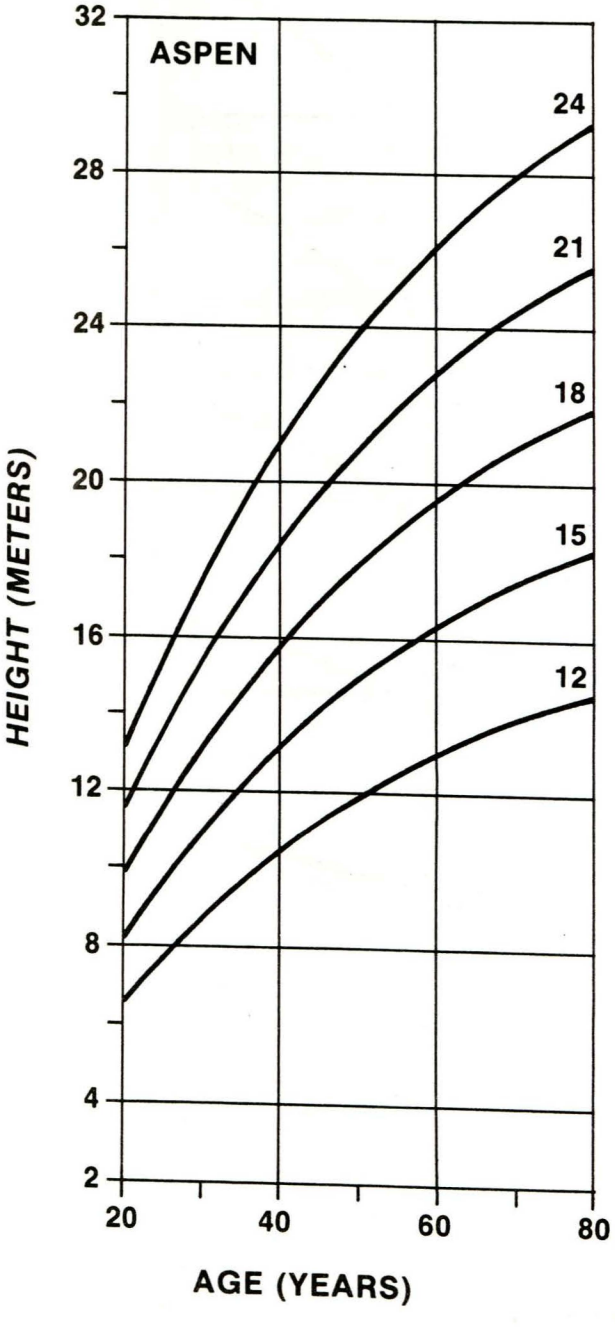

Figure 8.—*Aspen site index curves.*

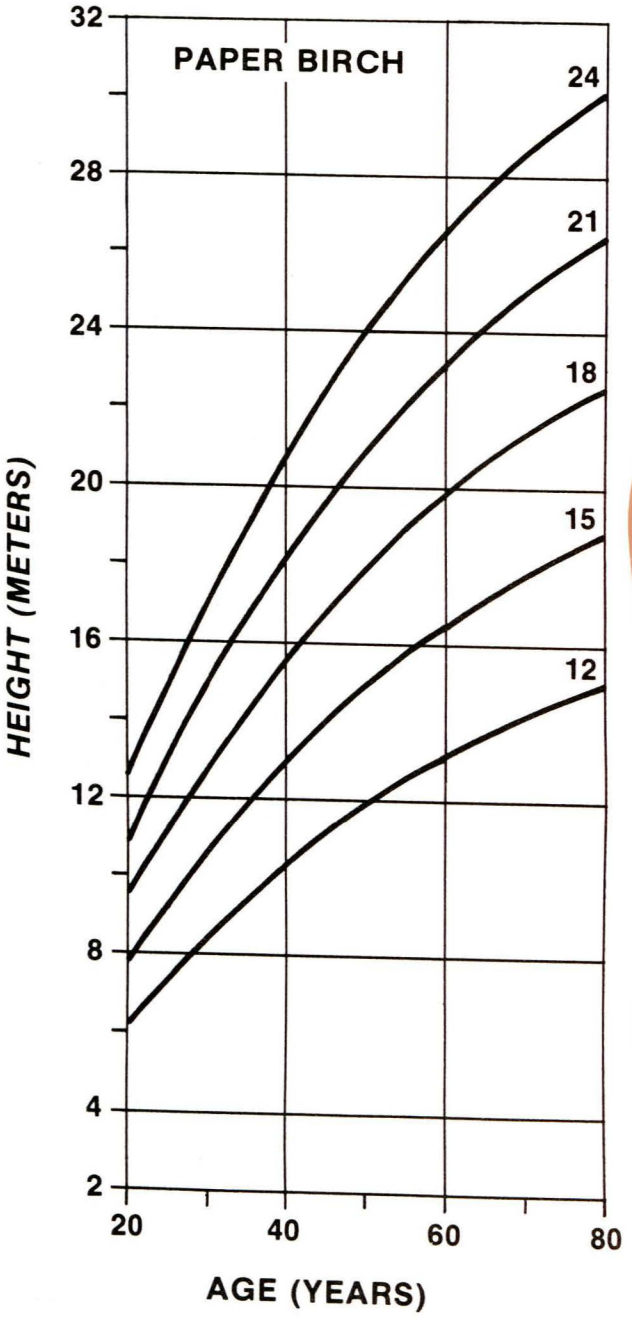

Figure 9.—*Paper birch site index curves.*

Laidly, Paul R.
1979. Metric site index curves for aspen, birch, and conifers in the Lake States. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. NC-54, 15 p. U.S. Dep. Agric. For. Serv., North Cent. For. Exp. Stn., St. Paul, MN.

Provides metric site index equations, tables, and curves for nine Lake States timber species.

OXFORD: 541(77). KEY WORDS: Red pine, white pine, jack pine, black spruce, tamarack, white-cedar, balsam fir.

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Man paints houses...

only nature should paint

trees and rocks.